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Issued August 22, 1911.

U. S. DEPARTMENT OF AGRICULTURE,

OFFICE OF PUBLIC ROADS—BULLETIN NO. 36.

LOGAN WALLER PAGE, DIRECTOR.

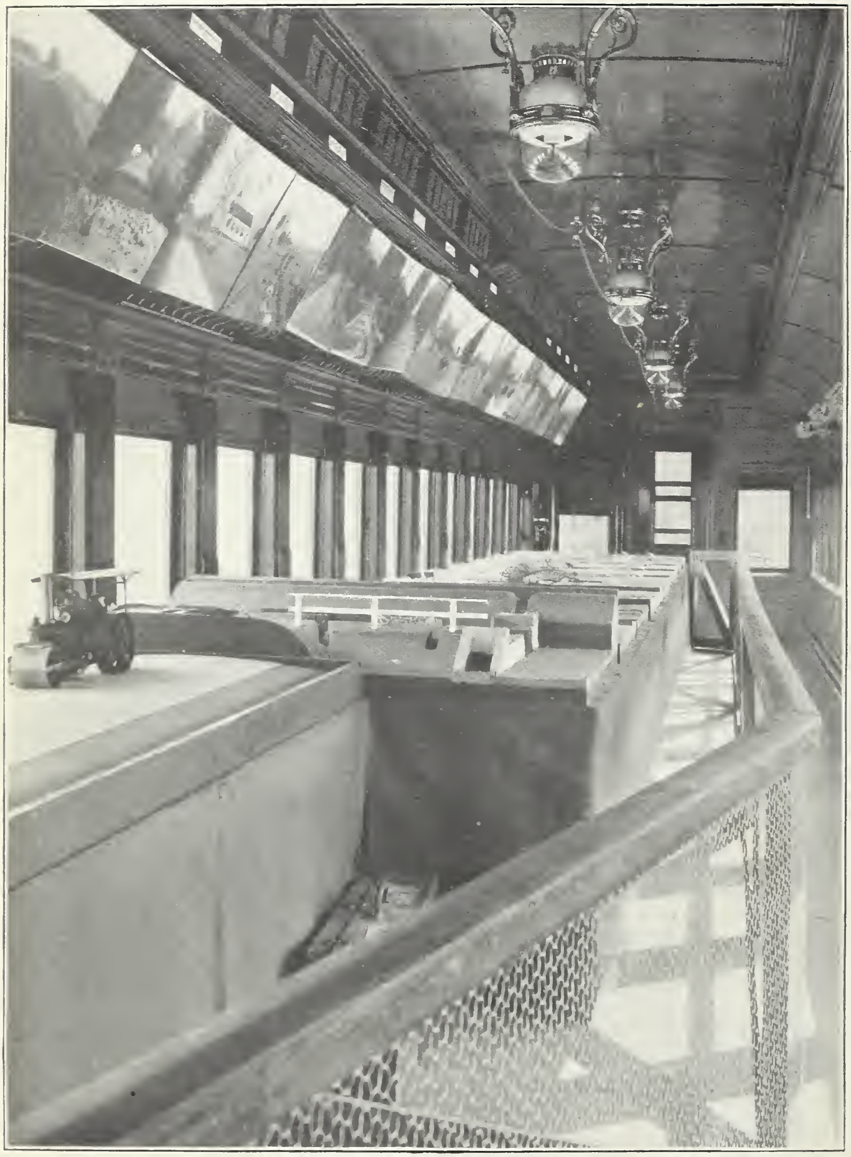
DESCRIPTIVE CATALOGUE

OF THE

ROAD MODEL EXHIBIT.

PREPARED BY THE OFFICE OF
PUBLIC ROADS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.



GENERAL VIEW OF OFFICE OF PUBLIC ROADS TRAIN EXHIBIT.

Issued August 22, 1911.

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OFFICE OF PUBLIC ROADS.

Logan Waller Page, *Director.*
Paul D. Sargent, *Assistant Director.*
Vernon M. Peirce, *Chief Engineer.*
Prevost Hubbard, *Chemist.*
Charles H. Hoyt, *Superintendent of Construction, in Charge of Bridge Engineering.*
M. O. Eldridge, *Assistant in Charge of Road Management Investigations.*
Albert T. Goldbeck, *Testing Engineer.*
Charles S. Reeve, *Assistant Chemist.*
Edwin C. E. Lord, *Petrographer.*
William W. Sniffin, *Editorial Clerk and Librarian.*
W. Carl Wyatt, *Chief Clerk.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Public Roads,
Washington, D. C., May 2, 1911.

Sir: I have the honor to transmit herewith a manuscript containing data which were first used in explaining the exhibit of this office at the Alaska-Yukon-Pacific Exposition. The models of the various kinds of roads are explained in detail, and information is included about several different road machines also. This publication was very useful when it was issued as a special handbook of the office exhibit at the Alaska-Yukon-Pacific Exposition, and, since at least the idea of that exhibit has been maintained and the collection of models as it now stands is frequently used to much advantage, it has seemed advisable to continue printing this information in the present form. Some of the old models have been abandoned, while others have been improved and several new ones have been added. The discussion about the different classes of roads is particularly valuable and instructive. There was a large demand for the bulletin in its previous form, and I now request that it be printed as Bulletin 36 of this office.

Respectfully,
Logan Waller Page,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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DESCRIPTIVE CATALOGUE OF THE ROAD MODEL EXHIBIT.

INTRODUCTION.

In assembling the exhibit shown by the Office of Public Roads of the United States Department of Agriculture, those responsible for this feature of the Federal Government's contribution to the Alaska-Yukon-Pacific Exposition sought to put on view such striking examples in miniature of road models that visitors would not only appreciate the beneficent effects of improved highways, but would, at the same time, be able to understand the methods of their construction.

Since the exposition closed, this exhibit has been displayed at Omaha, Nebr., during the National Corn Exposition; at Knoxville, Tenn., during the Southern Appalachian Exposition; at the National Land and Irrigation Exposition at Chicago, Ill., and at various places in the State of Pennsylvania. It has now been much improved and is to be used in various train exhibits in different parts of the country.

The models are standard types, and represent the most modern construction known to engineering science. Variations in construction will be necessary, owing to climatic conditions and the character of local materials, and on this point the Office of Public Roads stands ready, on application, to furnish, free of charge, expert advice covering any special problem. All of the models are built on a scale of 1 inch to the foot, or about one-twelfth full size. With the exception of the brick model, they represent roads with 16 feet of hardened surface, while the remainder of the surface is made up, on each side, of earth shoulders about 6 feet wide. Among the various types thus built to scale are models showing brick, earth, sand-clay, gravel, and macadam roads, and others showing the processes of maintenance, resurfacing, and bituminous macadam construction by the mixing, penetration, and prepared-filler methods. Another model shows the various methods of draining and strengthening poor soils for road foundations, while still another shows a typical method of treating gravel or macadam roads to prevent disintegration under automobile traffic and to make them dustless.

FOUNDATIONS OR SUBGRADES AND SHOULDERS.

In the construction of all types of gravel or macadam roads it is necessary, in order to obtain the best results and to use surfacing material economically, to prepare the foundation or subgrade and shoulders of the road carefully. The subgrade should be brought approximately to the grade established for the road, and as much lower as the depth of the surfacing material to be used. It should then be compacted with a roller until it is hard and firm. If soft places develop during the rolling, they should be filled with good material and rolled again. This prevents the surfacing material from being pressed into the foundation, and consequently less material is required. The subgrade should also be finished with a crown for the reason just stated. If the surface is to be of uniform thickness, the crown of the subgrade is the same as for the finished road. If the surfacing material is to be thicker at the center than at the sides, the subgrade must be made to correspond. The shoulders are built up before the surfacing material is placed in position and serve not only to increase the width of the road, but as a side support to hold the surfacing material while it is being rolled. They also keep it from wasting away into the side ditches. After the hardened surface is completed, the shoulders should be finished to correspond; shoulders are usually finished with a sharper crown than is given the hardened surface.

Plate II shows several methods of improving and strengthening poor natural foundations. This is accomplished principally by drainage, and as the need for some such treatment occurs more generally in hilly or rolling country than elsewhere, this model represents a roadbed located partly in a cut and partly on a sidehill.

Section A represents a sidehill location, and shows a surface ditch at the top of the slope, a side drain opening into a culvert with a drop inlet, a telford base, and a section of guard rail.

Section B shows a "V" stone drain foundation with a side outlet.

Section C shows a center drain with laterals and cobble gutters. Thus this model illustrates many solutions of the most important problem in connection with the construction of improved roads—the problem of drainage.

SECTION A—SURFACE DITCH, SIDE DRAIN, AND TELFORD FOUNDATION.

The surface ditch represented in this connection is often used to keep the surface water which falls on a large area sloping toward the road off of the road and out of the road gutters, where it often does considerable damage. The side drain is constructed to handle the ground water which is often found in hilly sections. In the model the trench is shown 2½ feet deep, 12 inches wide at the bottom, and 18 inches wide at the top. On the bottom of the trench are placed about 2 inches of clean stone and on this stone a tile pipe, usually about 5 inches in diameter, is laid. The pipe is laid without cement, and the loose stone is carefully filled around the sides and top of the pipe to the top of the trench. The side drain empties in some suitable outlet. For example, the one in this model empties in a drop inlet, which also serves as an outlet to the surface ditch. The drop inlet empties into a culvert and the water is carried under the road. This type of inlet furnishes an easy means for inspecting and cleaning the culvert. It also prevents the bank from sliding and closing up the inlet of the culvert, which sometimes happens in hilly sections.

The telford base is an old form of construction used largely in wet sections. The roadbed is excavated usually parallel to the surface of the finished road. Stones varying in length from 8 to 12 inches, in depth from 5 to 8 inches, and in thickness from 3 to 6 inches at the base to about 3 inches at the top are laid lengthwise across the roadbed on their broadest bases, with every other course breaking joints as nearly as possible. The points are broken off with hammers and the spalls used to wedge the surface together until a firm foundation has been secured.

The guard rail shown in the model is to protect travelers along the steep slopes. The fence is usually painted to prolong its life and colored white to enable the public to discern the embankment at night. The posts are about 6 inches in diameter and about 7 feet long, set in the ground to a depth of 3½ feet. About 18 inches from the ground a plank, 2 by 6 inches, is notched into the posts. The top rail is then placed about 18 inches above the top edge of this plank. It may be either a plank, 4 by 4 inches, notched into the top of the post or a plank, 2 by 6 inches, spiked to the top of the post which has been sawed off with a slope of 3 inches.

SECTION B—"V" STONE DRAIN FOUNDATION.

The "V" stone drain foundation is shown in section B of this model. This form of drainage is cheaper than the telford method and, in a section of country where rock abounds in ledges, it is also cheaper than the side-drain construction. It is used entirely in wet and spongy sections. The water is held at the point of the "V" until a suitable outlet can be secured. The center is usually excavated 2 feet and the sides about 16 inches below the finished grade. The material excavated is thrown to the sides, forming the shoulders. In swamp sections it is sometimes necessary to haul material for the shoulders. The "V" drain is then filled with stone to a depth of 18 inches at the center and 10 inches at the sides. These stones grade from 8 inches in thickness down to a few inches. The large-sized stones are placed at the bottom, while the small stones are used at the top. The surface should then be rolled and the surfacing material spread and rolled. "V" drains are sometimes built of brickbats, slag, or even sand, or any material that will permit the water to seep rapidly to the point of the "V." This type of construction permits the use of field stone of an inferior type and assists in clearing many farm lands of an otherwise waste product.

SECTION C—CENTER DRAIN WITH LATERALS AND COBBLE-PAVED GUTTERS.

The center drain with laterals, sometimes called a blind or French drain, furnishes another mode of draining the foundation of a road. Like the "V" drain, the water is brought to the center of the road and conducted to some suitable outlet. The model shows these drains about 2 feet deep, about 12 inches wide at the bottom, and about 18 inches wide at the top. The trench is filled with stones from a few inches in thickness up to 8 inches.

The cobble gutters show an effective way of handling surface water on steep grades. The stones vary in thickness from 8 inches to 12 inches and are laid on a sand or gravel base. They are well rammed and given a coat of sand which is carefully swept in, and then the road is rammed again. These gutters are easily cleaned and protect the banks from being undermined, while at the same time carrying the water along rapidly without damage to the road.

EARTH ROADS.

Plate III, figure 1, illustrates the construction and maintenance of an earth road. Earth roads should be worked when they are damp and soft. The material can then be handled more economically and the resulting road surface will be more satisfactory. After earth roads have once settled down in the spring or summer, they should not be disturbed. If work is then attempted, the material will be brought upon the road in clods, which make only a rough surface when dry and an excess of mud when wet.

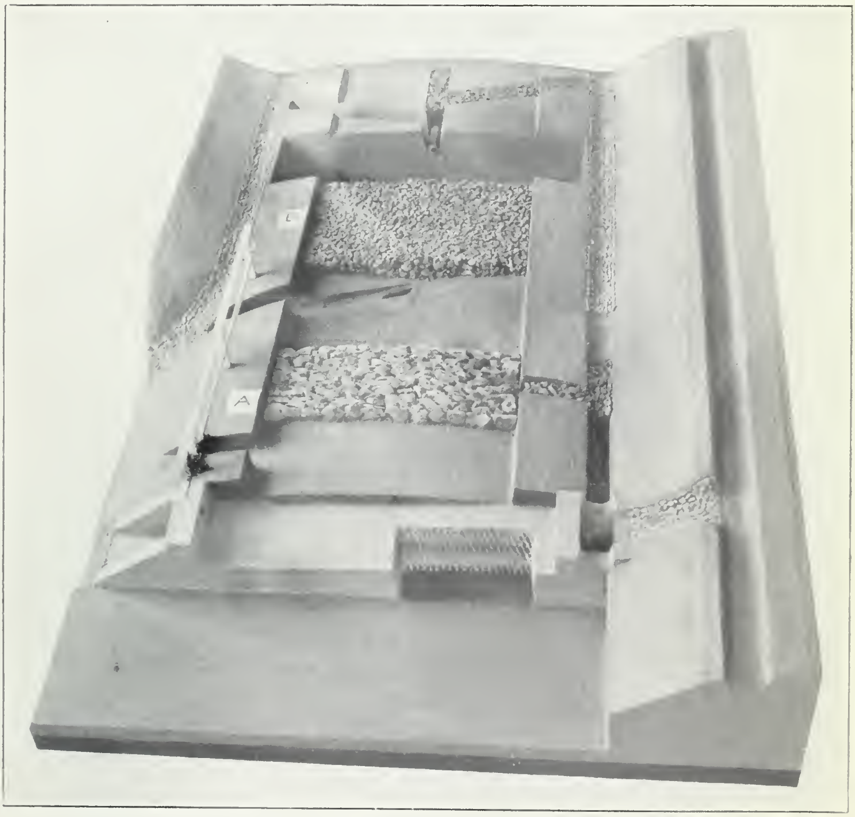
Section A shows the old and unimproved roadbed.

Section B illustrates a section of earth road under improvement, together with a road machine or grader. The width of the section shown is equivalent to about 33 feet of finished surface from ditch to ditch.

Section C illustrates an earth road which, though surfaced by a road machine, has rutted under heavy traffic and is being maintained by the split-log drag. In the road illustrated by sections B and C, the crown or slope from the center to the sides is equivalent to 1 inch to the foot.

The surface of section A is characteristic of altogether too many earth roads, in that the center is several inches lower than the sides. This faulty condition makes it impossible for the water to run from the surface; and, even if this were possible, there are no roadside ditches to carry it away. In consequence, the road is usually full of puddles, and cut up with ruts and mudholes.

Section B illustrates the use of a reversible road machine in opening roadside ditches and in shaping the road surface so that it will



Model Showing Various Methods of Road Drainage.

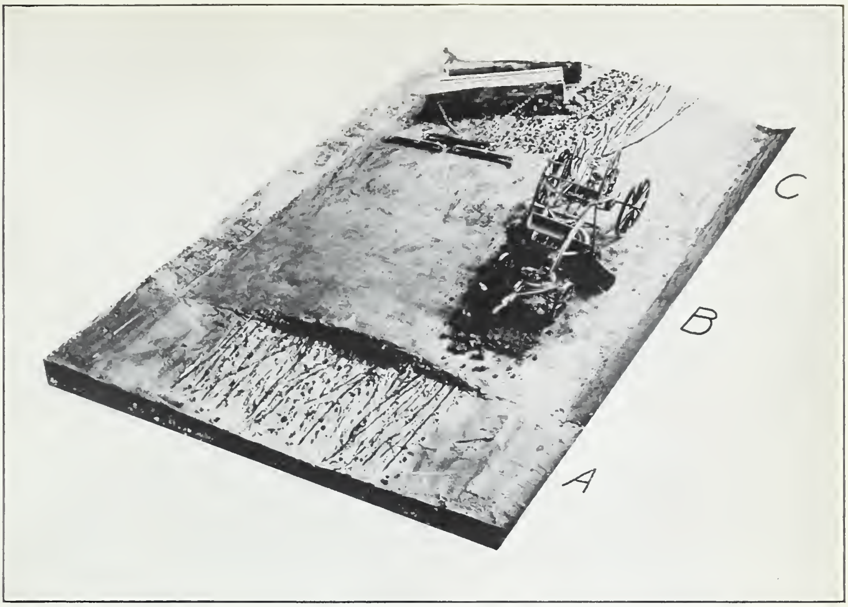


FIG. 1.—MODEL OF AN EARTH ROAD, SHOWING SPLIT-LOG DRAG AND ROAD GRADER IN OPERATION.

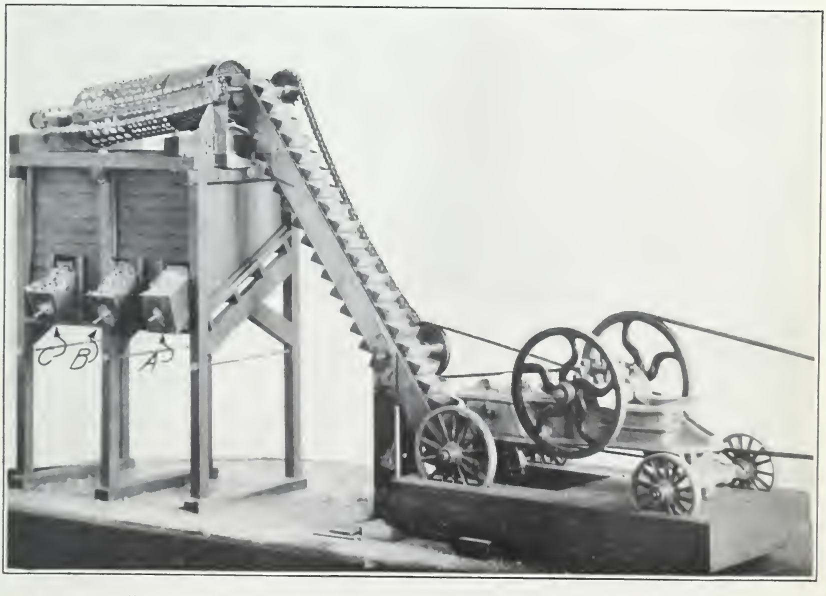


FIG. 2.—MODEL OF PORTABLE CRUSHING PLANT IN OPERATION.

shed water. The work of this machine is equivalent to the labor of many men, and it is done far better than can be done with shovels and picks. An earth road should have a width of at least 20 feet, or, better still, 24 or 30 feet. If the road is narrow, there is a tendency to use only the narrow central portion, and wagons running in the same rut soon create a water-holding depression. The surface drainage can be provided for by giving the road an average crown or slope from center to sides of 1 inch to the foot. On some soils the crown could be even less than that, but seldom greater. On all earth roads, except sandy sections, side ditches should be built as shown in section B. They can be made and maintained with a road machine, but care should be taken that they have a fall sufficient to carry the water along the side of the road. Through wet and swampy land it is often necessary to raise the roadbed above the general level of the country in order to secure drainage.

For continuous maintenance the split-log drag shown in section C has been devised. This little model has been built to the same scale as the road model—1 inch to the foot. It can be made best from a log 7 or 8 inches in diameter and from 6 to 8 feet long. The log should be carefully split and the halves fastened together with stakes, with the flat sides vertical and facing to the front. The logs, though of the same length, are attached so that the end of the rear log is from 16 to 20 inches nearer to the center of the road than the first one.

An ordinary trace chain and a set of doubletrees are then attached. When the horses move forward, the drag should slide along the road at an angle of about 45 degrees, with the forward end nearest the ditch, so that it moves the earth toward the road center.

In the construction of this implement care should be taken to make it light enough for one man to be able to lift it. The best material is a dry red-cedar log, though red elm and walnut are excellent, while box elder, soft maple, elm, or willow are superior to oak, hickory, or ash. A broad platform is usually placed on the cross stakes, helping to strengthen the implement and giving a place for the driver to stand. After a little practice, a man can learn how best to distribute his weight so as to make the drag cut, spread, and pack the earth properly.

Dragging across the ruts, up one side of the road and down the other, is all that should be undertaken the first time, but this should be repeated after each heavy rain. As a mile of road can be dragged in a few hours, the split-log drag provides a simple and inexpensive method of road maintenance. If it is used in conjunction with the road machine, fairly good earth roads can be secured at a nominal expense. Dragging is done for 50 cents per mile in some parts of the country. At this rate, a mile of earth road can be dragged once a month for a whole year for $6. Some remarkable results have been accomplished with the drag without the aid of the road machine. Farmers' Bulletin 321, "The Use of the Split-log Drag on Earth Roads," deals fully with this subject, and copies of this publication will be sent free to persons applying to the Secretary of Agriculture, Washington, D. C.

SAND-CLAY ROADS.

Plate IV illustrates the construction of a sand-clay road 16 feet wide and 8 inches thick when compacted. The crown as shown is 1 inch to the foot.

Section A represents an unimproved sand road about 33 feet wide.

Section B represents an old sand road slightly rounded to receive the clay, and with the center about 4 inches higher than the sides.

Section C shows a portion of road covered with clay to a depth of 6 inches.

Section D illustrates the harrowing or mixing process.

Section E shows the completed road.

From an inspection of this model it will be seen that the bottom of the ditch of a completed road of this type should be about 16 inches lower than the road at the center, so as to give an average slope of 1 inch to the foot.

As a general rule, sand-clay roads are built on sandy foundations and it is the usual practice to put the clay on the unimproved foundation, but better results will be obtained if the sandy foundation is given a slight crown. This makes the center from 4 to 6 inches higher than the side ditches. If this is not done, more clay will be necessary to give the road the needed crown, and that is expensive, especially if the material has to be hauled a considerable distance. The process is as follows:

The road is covered with from 4 to 6 inches of clay and worked with a disk or tooth harrow until thoroughly mixed, first dry and finally wet. The final mixing should be done, if possible, during rainy weather. When the mixing has been done, the surface is brought to a crown with the road machine or split-log drag and covered with a thin layer of sand. After two or three rains it may be found necessary to apply another sand coat. This method produces a smooth, cheap, and satisfactory road suitable for light traffic.

Similar results can be secured by adding sand to a clay road and providing good surface drainage. When building on a clay foundation, it is advisable to plow the clay before adding the sand in order to insure a thorough mixing. Farmers' Bulletin 311, "Sand-clay and Burnt-clay Roads," and Circular 91 of this office, "Sand-clay and Earth Roads in the Middle West," give full information on this subject.

GRAVEL ROADS.

Plate V illustrates a properly constructed gravel road 16 feet wide, 6 inches thick at the center, and 4 inches thick at the sides when rolled. The crown as shown is three-fourths inch to the foot. The road is graded for a width of 33 feet.

Section A represents a subgrade or foundation prepared as previously described, with the center about 10 inches higher than the bottom of the side ditches.

Section B shows the first course of gravel, which, after rolling, has a depth of about 4 inches at the center and about 3 inches at the sides.

Section C represents a second course after rolling. There the material is about 2 inches in depth at the center and 1½ inches at the sides. The crown or slope of this road from center to sides is at the rate of three-fourths inch to a foot. In constructing a gravel road the best results will be obtained by separating or screening the materials into sizes. For the bottom course material ranging from 1¼ inches to 2½ inches should be used, while for the top course material ranging from 1¼ inches to one-fourth inch should be used. The best and cheapest method of screening gravel is by using the rotary screen, with holes 2½, 1¼, and three-fourths inches wide. Gravel should contain from 16 to 20 per cent of clay or other binding materials to bond it properly. Roads of this type should be constructed as early in the spring as possible in order to give them time to consolidate thoroughly before the fall and winter rains.

This section also shows how the shoulders shown in sections A and B are finished to correspond with the gravel surface. When plenty of gravel can be obtained cheaply, it will be found more satisfactory to use it for surfacing the whole width of the road rather than to use it as above described with earth shoulders. When it is used in this way, the gravel surface may taper from 6 inches in thickness at the center to 2½ or 3 inches at the edge of the road.

MACADAM ROADS.

WATER-BOUND MACADAM ROADS.

Plate VI illustrates the construction of a macadam road 16 feet wide, 6 inches thick at the center, and 4 inches thick at the sides when rolled. The crown as shown is five-eighths inch to the foot. The road is graded for a width of 33 feet.

Section A represents the prepared subgrade properly crowned and rolled.

Section B represents the first course of broken stone 4 inches thick compacted.

Section C represents the second course 2 inches thick compacted.

Section D represents the finished road, an example of which is shown in Plate VII. In the model the crown or slope of the foundation is about the same as in the finished road, giving an average fall of about three-fourths inch to the foot from center to sides. In preparing for the construction of a road of this type it is advisable to roll the foundation thoroughly when the soil is damp, so that all soft spots may be found and filled, and that the ground may be prepared firmly and smoothly for the first layer of stone. Shoulders are built on both sides to hold the macadam in place, either by excavation or by piling up the earth shoulder as the work progresses. The shoulders should never be less than 3 or 4 feet wide, and, if possible, they should be 6 or 8. If they are sufficiently wide and have a slope of not more than 1 inch to the foot, they can be used in dry weather for light traffic, and thus relieve the macadam of fast travel, which causes it to ravel.

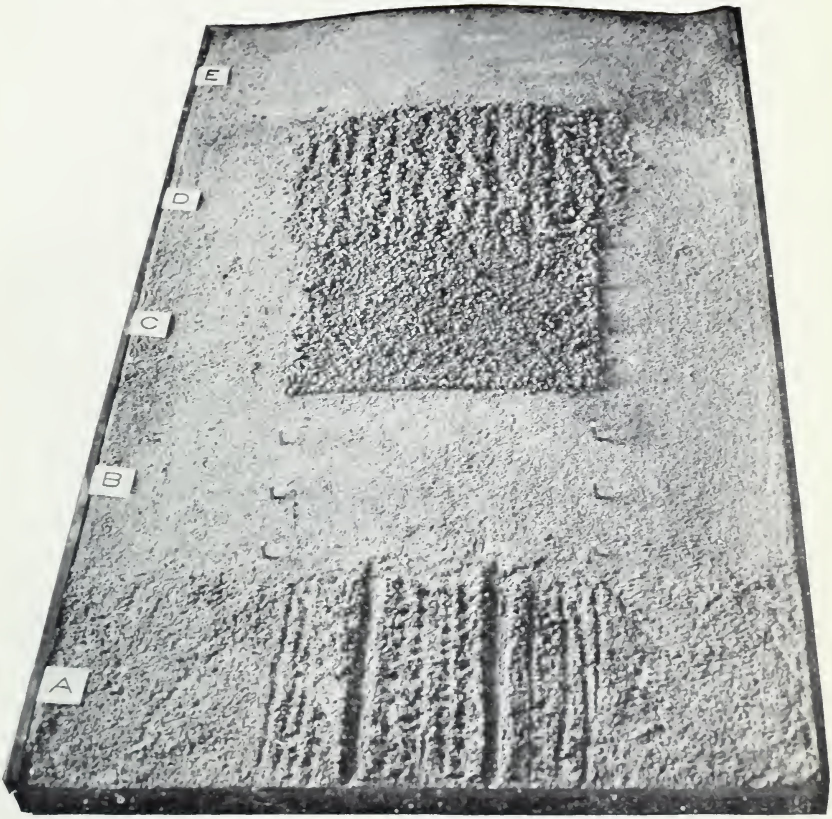
In every case the bottoms of the side ditches should be lower than the road foundation to insure proper drainage. If the road is built of clay or heavy soil, shoulder drains should be built at low places to lead the water from the foundation to the side ditches. These drains are filled with crushed rock or gravel and are covered with soil. The side ditches should be shallow, but wide; their construction is based on the volume of water they may be expected to carry.

The No. 1 crushed rock for the foundation may vary in sizes from 2 to 3½ inches in diameter. The depth of this course must depend upon the conditions. If built on light gravelly soil, where little traffic may be looked for, a depth of 3 or 4 inches is sufficient, but for heavy soils and constant traffic the course should be from 4 to 6 inches deep after rolling. For roads 12 feet wide or less the depth of material should be uniform throughout, but if the road is from 14 to 16 feet wide the total depth of both courses may be reduced to 6 inches at the center and 4 inches at the sides.

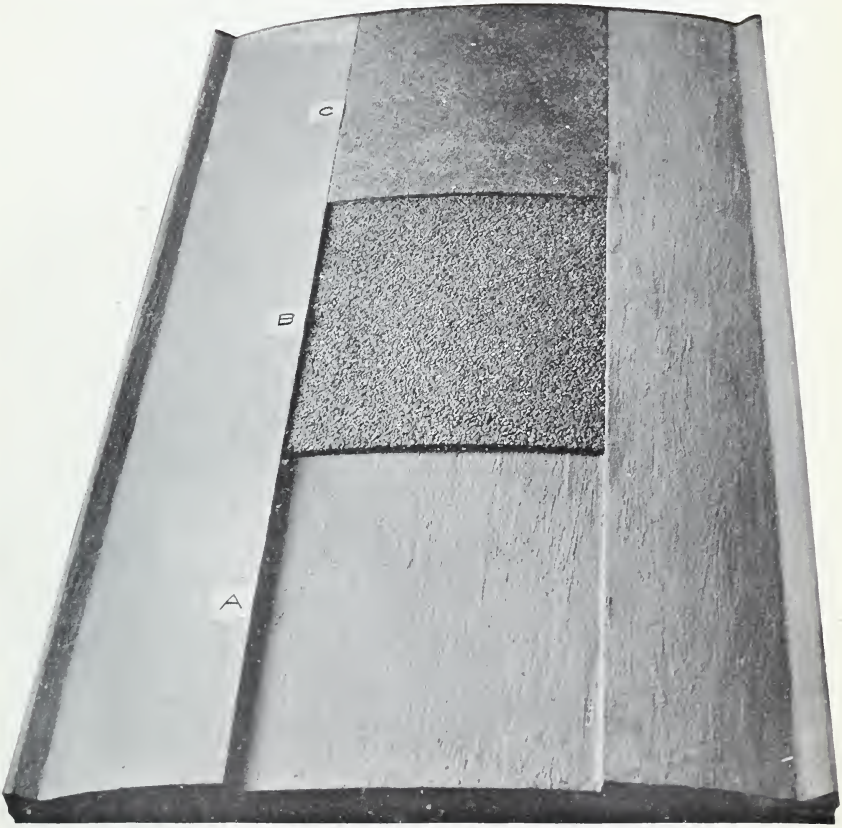
After the foundation course has been thoroughly rolled, the second course, varying in size from 1 to 2 inches, is applied. While rock of inferior quality may be used for the foundation course, nothing but the best hard and tough rock should be used for the surface. It should not only be able to resist the pounding and grinding of traffic, but should have a high cementing value so that the fine particles will bind the surface into a water-shedding crust. All rolling should start at the side and continue toward the center.

The final course of screenings does not add to the depth of the road, which when completed should be flush with the earth shoulders. The total depth of roads of this type varies from 4 to 12 inches, according to local conditions, but the average depth of such roads in the United States is not more than 6 or 7 inches.

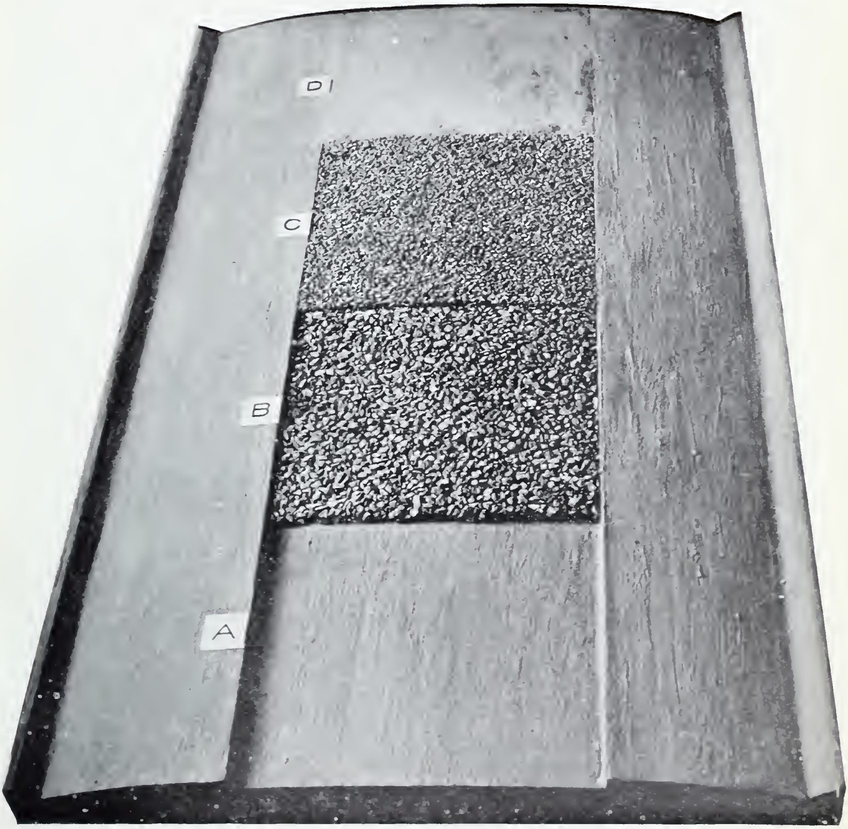
In spreading the surface-bonding course of screenings, the stone may vary from three-fourths inch down to dust. It is not neces-



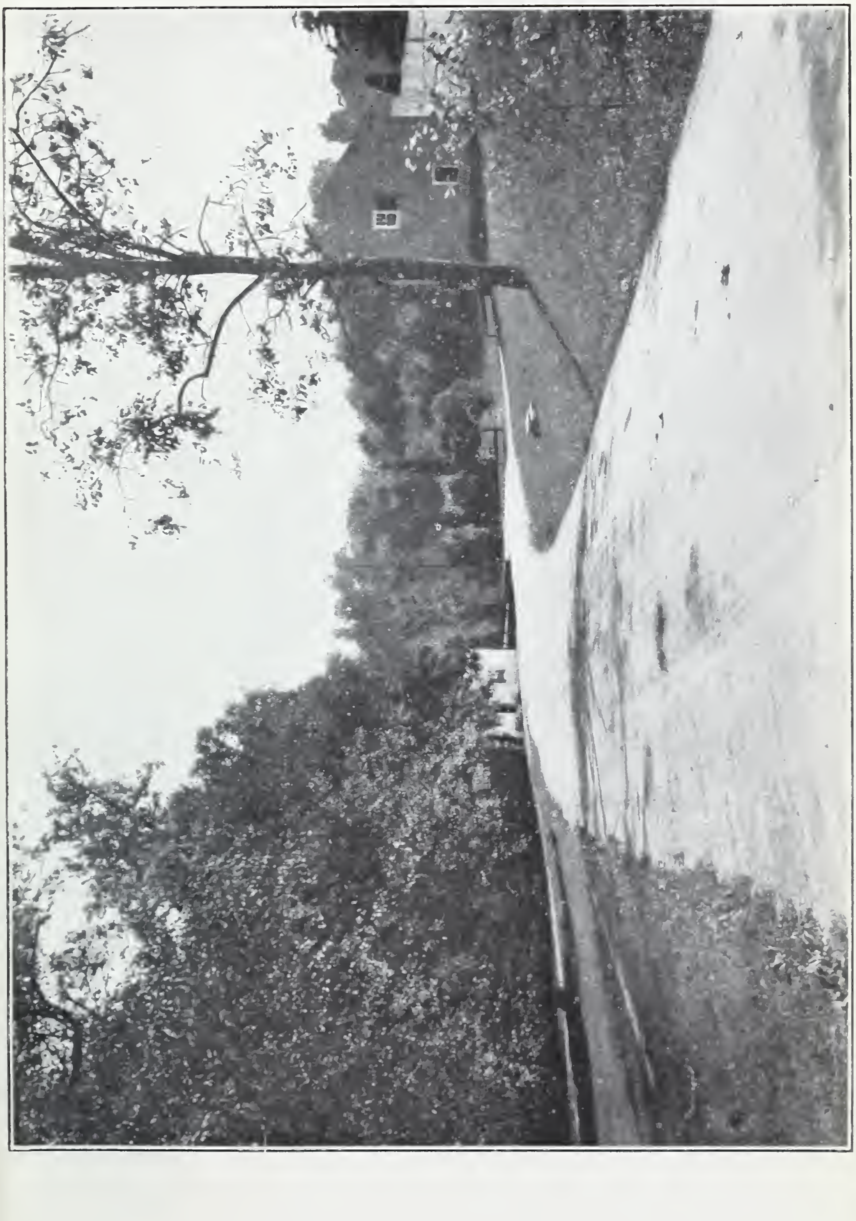
MODEL OF A SAND-CLAY ROAD.



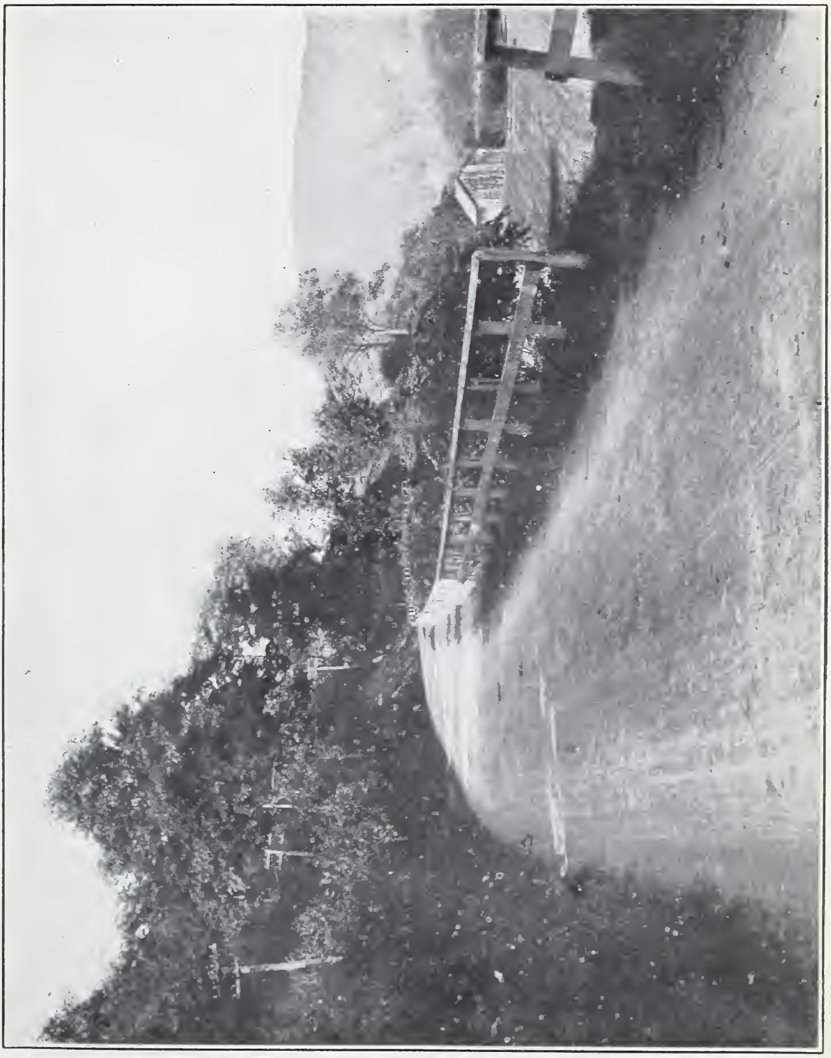
MODEL OF A GRAVEL ROAD.



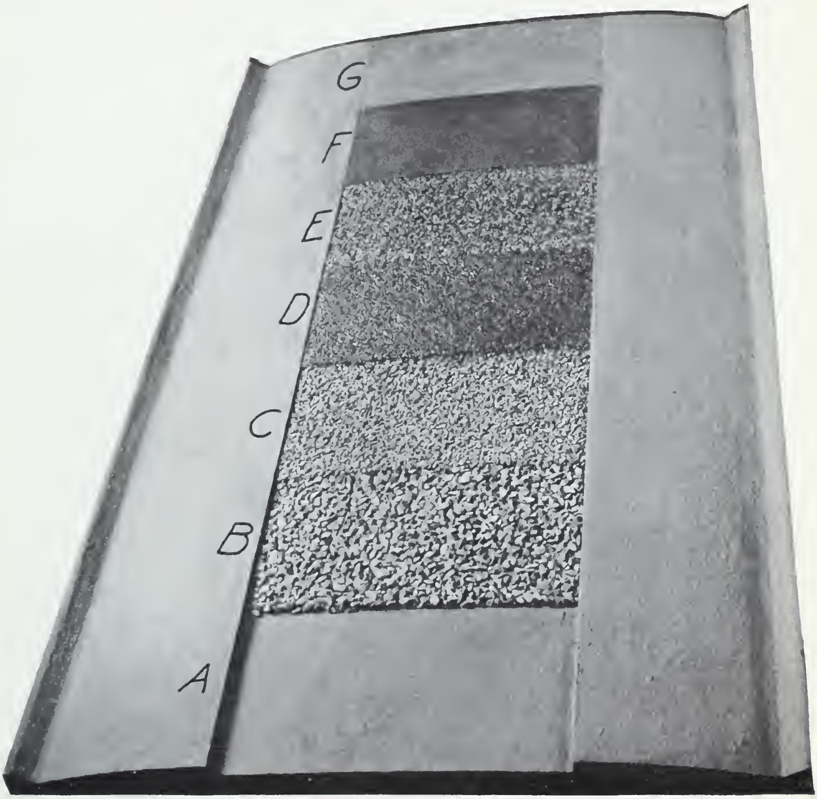
MODEL OF A WATER-BOUND MACADAM ROAD.



MACADAM ROAD, ROCK CREEK PARK, DISTRICT OF COLUMBIA.



MACADAM ROAD WITH V-SHAPED FOUNDATION AT RUSSELL, MASS.



MODEL OF A BITUMINOUS MACADAM ROAD—PENETRATION METHOD.

sary to separate the dust from the screenings unless the amount of dust is excessive. If too much dust is used, the road will be sloppy in wet weather and dusty in dry; while, if there is not a sufficient quantity of screenings, the road will quickly ravel, especially under fast automobile traffic.

Care and judgment must be exercised in determining the proper amount of screenings and also in spreading them. One thin layer should be spread and rolled, and, after it has been sprinkled and thoroughly rolled, another should be spread. By continuing this process until all voids are filled and the surface has been thoroughly consolidated a waterproof surface will be secured.

In the foreground of the frontispiece (Pl. I) is shown a miniature steam roller, which is intended to emphasize the importance of road rolling. In the long run better and cheaper work can be done with a power roller than with a horse roller, and this type may also be used to advantage in road repair work. If the road surface becomes uneven or rutted, it can be spiked up by teeth placed in the wheels of the roller. Then the surface can be leveled off and resurfaced with another course of No. 2 stone, after which it may be rolled and treated again with screenings. Farmers' Bulletin 338, "Macadam Roads," gives additional information on this subject.

BITUMINOUS MACADAM ROADS.

PENETRATION METHOD.

Plate IX illustrates the construction of a bituminous macadam road built according to the penetration method.

Section A represents the prepared subgrade 16 feet wide, with the crown one-half inch to the foot.

Section B represents the first course of No. 1 stone, 4 inches compacted after rolling.

Section C represents the second course of No. 2 stone, 2 inches compacted after rolling.

Section D shows the application of bitumen at the rate of about 1½ gallons to the square yard.

Section E shows the application of stone chips after being rolled.

Section F shows a bitumen paint coat applied at the rate of about one-half gallon per square yard.

Section G shows the completed surface with clean stone chips lightly rolled, and the crown of the finished road representing an average fall of about one-half inch to the foot.

The construction of this road, through the application of the No. 1 and No. 2 courses, is the same as an ordinary macadam road. It varies from the method of construction of a macadam road in that hot tar or asphalt is flushed into the No. 2 course before the screenings are applied.

After the application of hot tar or asphalt a light coat of clean stone chips is spread and rolled lightly into the surface. Following this process a paint coat of hot tar or asphalt is applied and another layer of screenings spread and rolled into the surface.

MIXING METHOD.

Plate X illustrates the construction of a tar, oil, or asphalt macadam road, built according to the plan ordinarily referred to as the "mixing method."

Section A illustrates the prepared subgrade 16 feet wide, with the crown one-half inch to the foot.

Section B represents the first course of No. 1 stone compacted to a depth of about 4 inches.

Section C represents the second course of bitumen-covered stone spread to a depth of about 2 inches when compacted.

Section D represents the application of about a one-fourth inch layer of bitumen-covered sand or stone chips, which, after being rolled firmly into the surface voids, should add nothing to the thickness of the road.

Section E shows the completed surface and the clean chips or sand lightly rolled, leaving the road with a sloping crown of about one-half inch to the foot. The course of bitumen-covered stone is prepared by applying sufficient hot bitumen to cover a graded mineral aggregate when mixed. This graded aggregate is composed of No. 2 stone and stone ranging in size from three-fourths inch to dust in proportions of 960 pounds to 350 pounds.

Before applying the bitumen-covered sand this course must be thoroughly rolled and the sand then applied in such quantities that it will fill the surface voids and bring the surface to a smooth and even condition. The final coat of stone dust is applied merely for the purpose of taking up any excess of bitumen and of giving the road a pleasing appearance.

PREPARED-FILLER METHOD.

Plate XI shows the construction of a bituminous macadam road built according to the prepared-filler method.

Section A represents the prepared subgrade, which has a crown of three-fourths of an inch to the foot and is well rolled.

Section B shows the first course of No. 1 broken stone. The stone varies in size from 2 to 3½ inches and is placed to a depth of about 5½ inches loose or 4 inches rolled.

Section C represents the second layer of broken stone. The size of the stone in this layer varies from three-fourths of an inch to 2 inches. The stone is spread to a depth of about 3 inches loose or 2½ inches rolled.

Section D illustrates the application of the bituminous prepared filler, spread to a depth of about 1½ inches. The filler is made up as follows: Stone chips from one-eighth to three-fourths of an inch, sand, and from 7 to 12 per cent bitumen, each heated separately and mixed. The mixture is applied hot.

Section E represents the mixing of the prepared filler with the No. 2 stone, by means of harrowing. The prepared filler is harrowed until the No. 2 stone appears in the surface, after which it is thoroughly rolled with a steam roller.

Section F represents the second layer of prepared filler, which is spread to a depth of about one-half inch and thoroughly rolled.

Section G shows the application of a light covering of screenings to take up the surplus bitumen, after which a thorough rolling completes the road.

MAINTENANCE OF MACADAM ROADS.

SURFACE TREATMENT.

The surface treatment of an old macadam road with tar or oil is shown in Plate XII.

Section A shows a disintegrated macadam surface.

Section B shows the surface after sweeping.

Section C shows the application of oil or hot tar at the rate of about one-half gallon per square yard.

Section D shows the application of sand to the oiled surface, and thus completes the treatment. In applying tar or oil a number of methods may be adopted. It may be poured by hand, or by means of a sprinkling wagon. The liquid should be thoroughly broomed into the oil surface before the sand is applied, in order to secure perfect cohesion. Before any application of oil or tar is made, all loose material should be removed and the road surface should be absolutely dry. Enough sand should be applied to take up any excess of tar or oil that may be left on the surface.

RESURFACING MACADAM ROADS.

Plate XIII illustrates the restoration of a macadam road to its original condition after it has become badly worn, owing to lack of maintenance. The macadam width as shown is 16 feet, and the crown is one-half inch to the foot.

Section A illustrates the worn macadam surface.

Section B illustrates the surface after spiking.

Section C illustrates the road after it has been recrowned.

Section D illustrates the application of 2 inches of new stone compacted after rolling.

Section E illustrates the application of tar or asphalt by the penetration method at the rate of about 1½ gallons per square yard.

Section F illustrates the application of stone chips after being rolled.

Section G illustrates a tar paint coat averaging about one-half gallon per square yard.

Section H illustrates the finished surface. This model illustrates the usual custom of restoring a macadam road which has become badly worn and rutted, owing to excessive travel and lack of maintenance. It shows that, unless roads are given proper maintenance at the proper time, it will become necessary to make extensive repairs at some time in the future.

BRICK ROADS.

Plate XIV illustrates the construction of a brick road where frost conditions are encountered, and differs from the other models in that the surface width is 14 feet, including the curb. The crown of the completed roadway is three-eighths inch to the foot.

Section A illustrates the prepared subgrade for the foundation course.

Section B illustrates the concrete curbing placed along the edges of the road.

Section C illustrates a stone foundation 6 inches deep.

Section D illustrates a concrete foundation 6 inches deep, which is often used in place of the stone foundation.

Section E illustrates the sand cushion 2 inches deep, placed on top of the foundation previously described.

Section F illustrates the surface before grouting.

Section G illustrates the expansion joints.

Section H illustrates the grouted brick surface ready for travel. In addition, a properly constructed mixing box is shown, illustrating the manner in which the grouting is prepared.

ROAD MACHINERY.

CRUSHER PLANT.

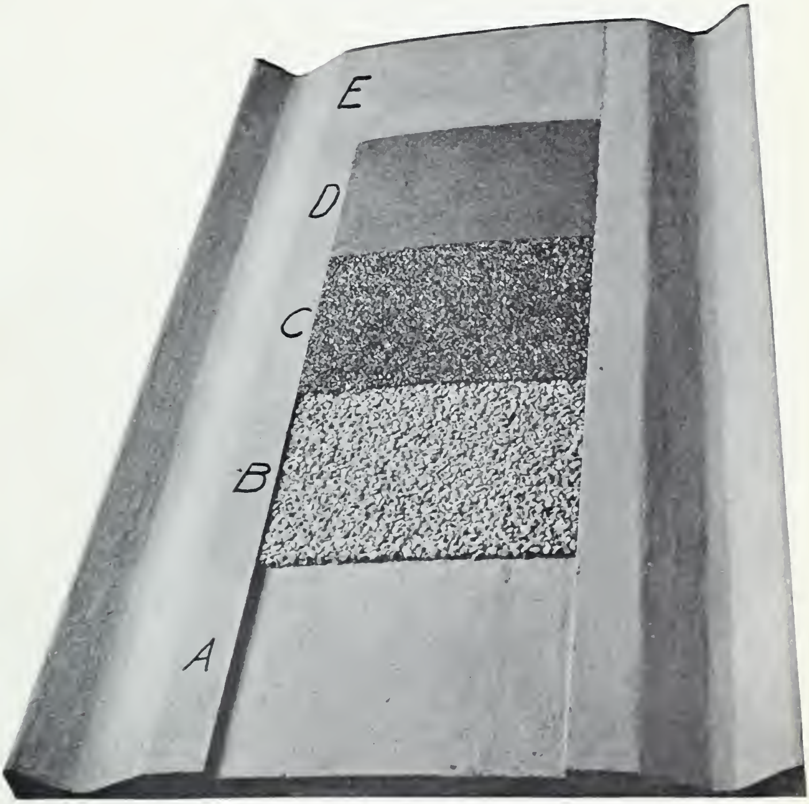
Plate III, figure 2, represents a portable stone-crusher plant.

Section A illustrates the stone screenings, commonly called "pea" size.

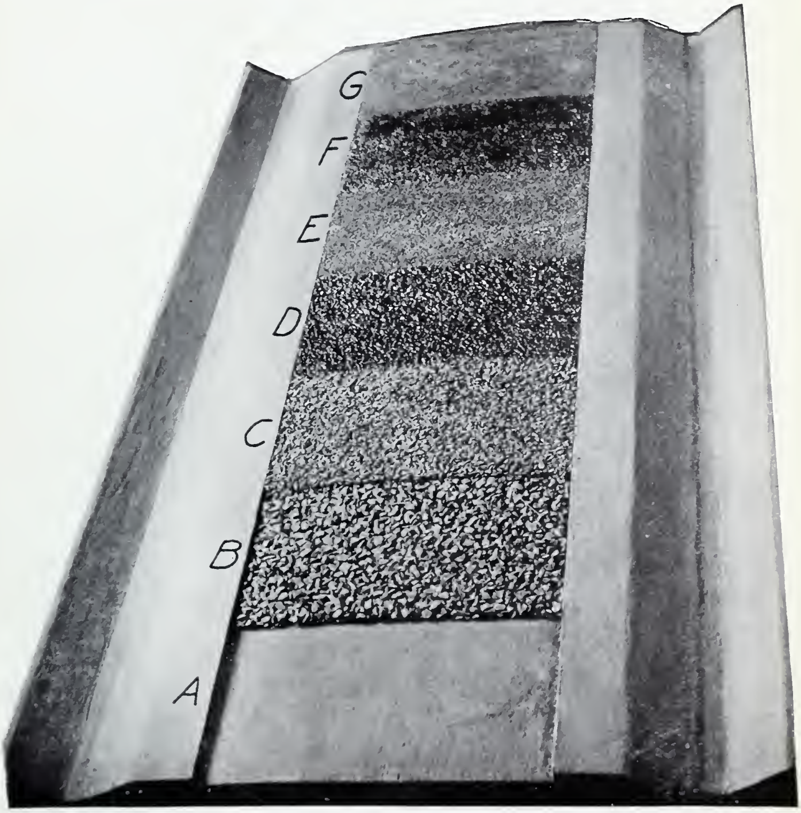
Section B illustrates the second course of stone, commonly called "nut" size.

Section C illustrates the first course, commonly known as "egg" size.

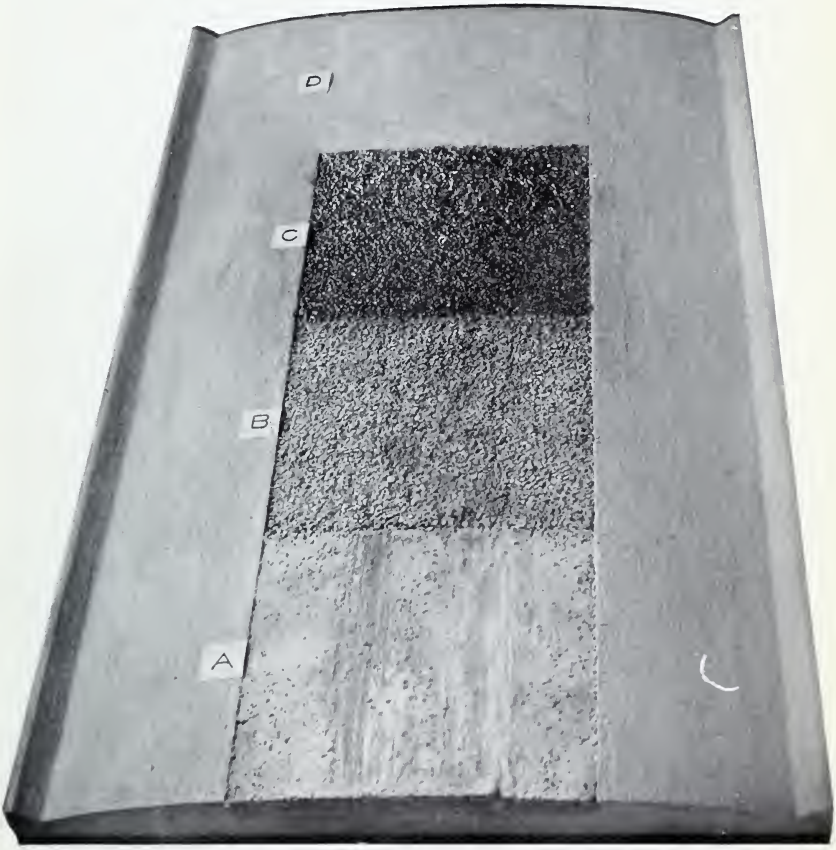
A stone crusher plant is indispensable in the construction of first-class stone roads and, if such work is to be done well and cheaply, the plant must be complete and conveniently arranged.



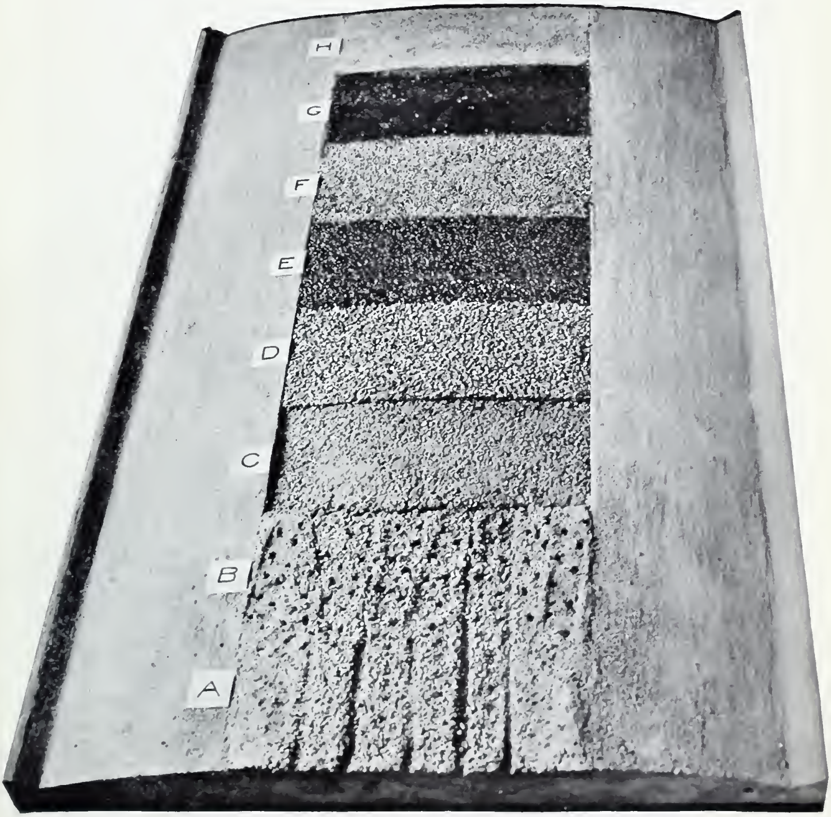
MODEL OF A BITUMINOUS MACADAM ROAD—MIXING METHOD.



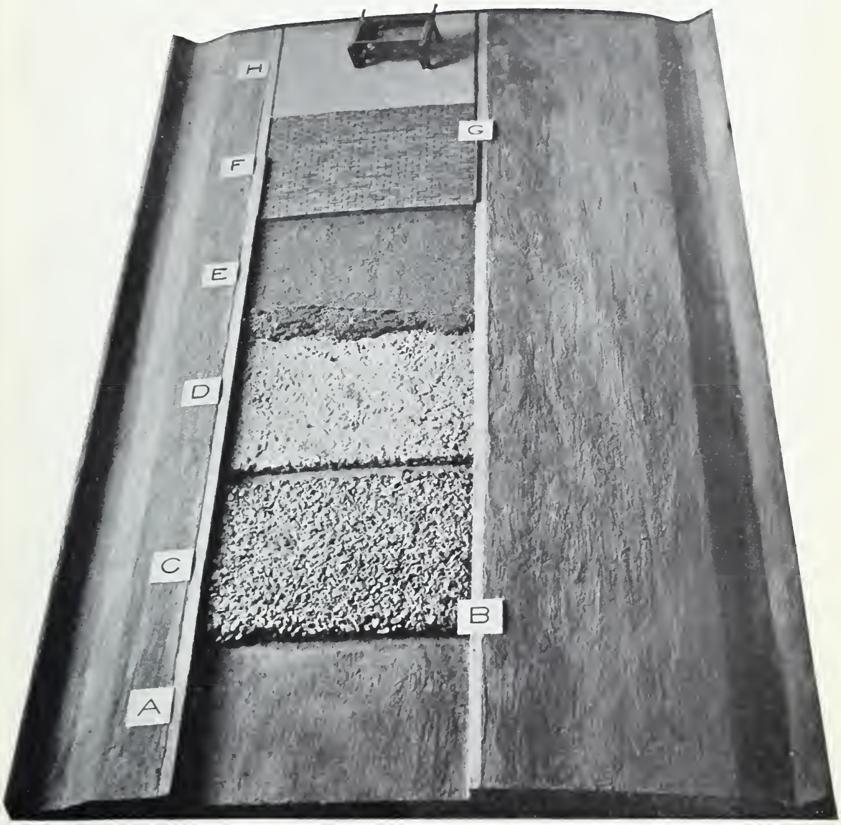
MODEL OF A BITUMINOUS MACADAM ROAD—PREPARED-FILLER METHOD.



MODEL SHOWING MAINTENANCE OF MACADAM ROADS—SURFACE TREATMENT.



MODEL SHOWING MAINTENANCE OF MACADAM ROADS—RESURFACING ROAD.



Model of a Brick Road.

Sometimes the crusher can be located so near the quarry that the rock may be sent down grade in tramcars and delivered to the mouth of the crusher by gravity, thus rendering lifting by hand unnecessary. The crusher should be provided with an elevator and with screens for separating the material into proper sizes. The screens should be divided so that through the section near the upper end may pass fragments not exceeding one-half inch in size, while the second section will allow the passage of stones less than 1¼ inches, and the third section will permit stones less than 2½ inches. Any larger stones will be forced through the opening at the end of the screen, from which they will drop into the tailings conveyor, to be crushed finally or eliminated from the work. The jaws of the crusher should be set so as to make as few tailings as possible.

When soft stones are being crushed, a dust jacket having a 1½-inch mesh may be placed over the first section to eliminate dust from the screenings. For receiving the various sizes of crushed rock, bins with slanting metal bottoms and sliding doors should be provided, so that the materials can be loaded into wagons by gravity.

Two types of crusher are now commonly used, one the jaw crusher as shown in Plate III, figure 2, and the other the gyratory crusher. The jaw crusher is generally used for portable plants. In this machine, one of the jaws moves backward and forward by means of a toggle joint and an eccentric, and the stone descends as the jaw recedes. As it returns, it catches the stone and crushes it. The maximum size of the product is determined by the distance between the jaw plates at the lower edge.

The gyratory crusher consists of a solid conical iron shaft, supporting a heavy mass somewhat like an inverted bell. By means of an eccentric a rotary motion is given the shaft so that every point of its surface is successively brought near the surface of the "bell," and the rock caught between the shaft and "bell" is crushed.

The gyratory crusher will not produce as many flat pieces or tailings as the jaw crusher, because the stones have to come in contact with two curved surfaces at the same time before they are broken.

ROAD GRADERS.

This model (fig. 1) shows in miniature a machine which is used in building earth roads and in preparing the subgrade for macadam roads. The frame, which is on wheels, supports an adjustable scraper blade, the front end of which may be used to plow a furrow, while the rear end pushes the earth toward the center or distributes it smoothly. The blade may be set at any angle or tilted either backward or forward.

In building the earth road with the road machine a furrow is first plowed with the point of the blade where the outside of the ditch is to be located. The blade may be made to penetrate hard or stony ground by elevating the rear end considerably and by using only the point of the blade for such plowing.

The team should be driven so that the point of the blade will follow the furrow made on the first trip, plowing a full furrow with the advance end of the blade and with the rear end dropped somewhat lower than before.

The machine should be guided gradually toward the middle of the road, so that it will move the earth previously plowed toward the center. This is done by slightly elevating the rear end of the blade to allow the earth to distribute under it and to give the necessary crown to the sides of the road.

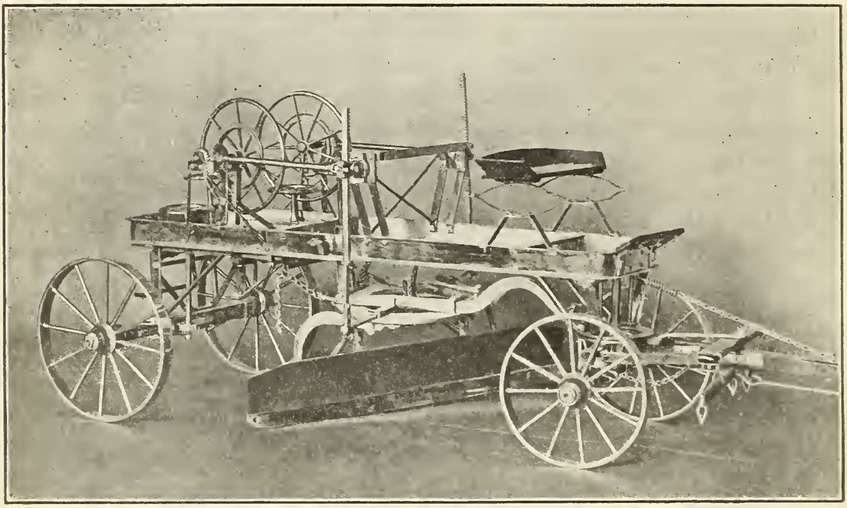


FIG. 1.—Model of road grader.

It is advisable to use the machine when the ground is pliable, best of all in the early summer, in order to give the loose earth time to settle and pack before the fall rains. If the work is done in the fall, not more than 3 or 4 inches of loose earth should be put on at one working.

If the side of the road is covered with sod, this should be removed from the road, and the earth from the side ditches should be used to replace it, if necessary.